

December 2015

nationalgrid

The future of gas

Delivering for our customers



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Foreword

by **John Pettigrew**
Executive Director, UK

Delivering and maintaining an energy supply which meets the needs of consumers and business today and tomorrow is what we do day in, day out. Whilst we have set out our vision for the next 35 years, there are still some important choices to make about our priorities for investment and focus for innovation in order to provide long term value, security and sustainability for the UK.

Working within the framework of shifting external and customer demands is nothing new of course. Since the creation of the energy system back in 1926 we have had to be flexible, such as a move from Town Gas to North Sea natural gas reserves, and the rapid move from centralised generation to renewable sources, including embedded generation has presented opportunities as well as challenges.

The current and future direction of energy policy and the shape, size and mix of the energy network in the UK is an increasingly hot topic; the role that gas can play in both the short and long term must be considered if we are to meet the demands of the energy trilemma – security, affordability and sustainability.

Our Gas Distribution business presentation, Energy 2050: Future of Gas, has laid out the wide range of external factors that need to be considered. How are customer needs likely to change? What are the trends that will shape future demand for energy, and for gas? How can we make sure that our energy mix is resilient in the future?

Changes in the UK population, age demographics, size of household and construction of high-standard, energy-efficient buildings will all have an impact on demand. The impact of fast-paced developments in technology and increased focus on driving innovation in the UK is also pushing change for the energy sector, as well as for the industries, businesses and customers we deliver for.

Our own gas production methods are evolving at a pace: for example, advances in biogas production from waste anaerobic digestion will see 50 plants operating in the UK. Through further technology developments, such as Gasification (a process that converts organic or fossil fuel based carbonaceous materials into power, transportation fuels, chemicals, fertilizers, and other valuable products) it will be possible to close the loop, turning our black bag waste back into energy. If we choose to use our waste to generate gas the UK could produce enough renewable gas to supply up to half our domestic usage by 2050.

National Grid's gas transmission network already ensures the safe and reliable transportation of gas to 23.2 million customers around Great Britain, and our customers are asking it to do more. We are ensuring the network can meet the flexible needs of our customers, so it can manage the changing flows within day and physically across the network. We are also responding to external drivers for change that directly affect our assets such as emissions legislation and responding to activity in the electricity market.

Finally, the focus on renewable and low carbon energy sources is being taken very seriously by other sectors. Take the development of Compressed Natural Gas vehicles by the road transport industry for example – how can we facilitate their move to decarbonise lorries and buses?

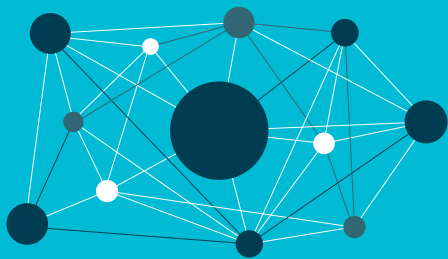
There are clearly some considerable opportunities and challenges in designing the shape of the future energy mix for the UK. This Future of Gas series will set out to consider what role gas has to play, how we might achieve it and how it will impact on us all.

But, of course, it's not just our story to tell... We would like to develop these thought provoking papers with the rest of industry, our peers and partners and so invite you to provide insight and comment as we develop this series.



J. Pettigrew.

The gas network of today



Current pipe network of

284,000 km

There are over

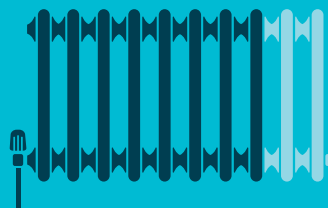
23m

gas customers across the UK, and around **60K new customers** are connected to the gas network each year.



107 billion showers

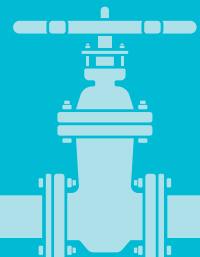
We currently use 321 TWh* to heat our homes (includes 35 TWh* for gas cooking). This is equivalent to 107 billion showers per year or 4800 per household.



Gas provides **4/5 of total energy demand** for heat at **peak times**

Gas Delivers
720 TWh*
of energy to customers
across the UK per year

* A kilowatt-hour (kWh) refers to a person using 1,000 watts of energy for 1 hour. Similarly a terawatt-hour (TWh) equals 1,000,000,000 kWh





of UK's current final energy consumption is used to provide heat related services in buildings and industry, and of this 2/3 is provided by natural gas



1/3 of all UK energy consumption is for heat provided by natural gas

99.99%
security of supply



Over 28,000km of the pipe upgrade programme will have been upgraded by 2021, with the remaining complete by 2032

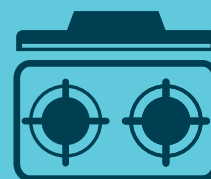
HISTORY

Gas was introduced just over

200

years ago in the UK – partly a bi-product of coke manufacturing (steel production).

Town gas expanded to the 1960's. Town gas was hydrogen and methane and it served circa 40 million appliances and 10 million homes.



However, power, coal, oil all had large market shares. Natural gas conversion and nationalisation started in the 1940s – gas replaced coal and power for heat mainly in cities.

The challenge and the opportunity

Why gas?

Gas has been an energy source in the UK for over 200 years, giving people easy access to affordable light, heat and power. The demand for gas grew, but so did the pollution and health problems associated with it. The discovery of natural gas in the North Sea, however, created the “perfect storm” for gas to dominate the energy mix by the 1970s. Natural gas not only offered a reliable supply, which was vital during the oil crisis, but it was also cleaner and cheaper for customers who were increasingly choosing central heating for their homes.

Today’s dilemma

So, why is energy being talked about so much? What’s changed in the energy market, in customer demand and in policy? The World Energy Council summed it up as the “energy trilemma” – a term that describes the difficulty in finding secure energy supplies and meeting rising demand while keeping prices affordable and reducing greenhouse gas emissions.

We’ve seen rapid rises in fuel prices and, as the North Sea’s riches have dwindled far sooner than many had expected, the UK has become a net importer of fuel. The affordability and security aspects of the trilemma have therefore quickly jumped up the political agenda.

Getting the balance right

The key question is “What should the UK do to get the energy balance right if we’re to have a secure, reliable, affordable and sustainable supply for the future?”

Affordability

The rising cost of energy over the past decade has had a significant impact on consumers and coupled with other external factors, such as the financial crisis, have led to a dramatic growth in fuel poverty. According to the Department for Energy and Climate Change, 1 in 5 households are now living in fuel poverty.¹

Given these trends, we must consider the role gas can play in managing costs and offering reasonable pricing to customers. Since the introduction of the network fuel poverty allowance the industry

has connected over 44,000 vulnerable customer homes to the network and by 2021 will have connected a further 91,200 to this lowest cost energy option.

Affordability can go hand in hand with the efficient use of energy. So how do we accelerate the adoption of energy-efficient technologies, such as A-rated boilers and smart thermostats, to help customers reduce waste?

Sustainability

The move to decarbonise (that is, cut down carbon emissions) has had a huge impact across all industries from power, to heat and transport.

The task, then, is to meet sustainability targets. We need to do this in an affordable way while also ensuring a supply on the coldest days and during peak demand.

Perhaps it’s time to question the policy for electrification and consider how gas could offer a solution. Should we use and store different forms of energy? What can we do with excess electricity energy when the demand is low? What is the role for renewable gases?

Security of supply

Worrying about keeping the lights on may be a distant memory for many of us. But with increasing demand from a growing population, which is also getting disproportionately older, how do we guarantee that the network supply will continue to meet our needs every day of the year?

We need to acknowledge that demand will not be evenly spread across the UK as the population grows and ages. So the network should be able to balance the differences, locally and nationally.

Our network

A key focus has been on the programme to replace iron gas pipes. This will result in a better network for the future, with low wastage and low leakage. The programme to replace the iron mains has been ongoing since the 1970s and in recent years has been accelerated and 28,204km will have been replaced between April 2013 and March 2021.

Also, by introducing new sources of gas into the existing network, we can use an asset we already have, at minimal extra cost. And it means we can help to improve the reliability of the UK’s energy infrastructure.

Our commitment

As an industry, we need to better understand the opportunities gas can bring us in the UK, particularly in the context of four priorities for our customers: supply of natural gas, domestic heat, transport and network capability.

We are committed to finding low-cost ways to meet our carbon reduction targets.

1. DECC Annual Report of Fuel Poverty 2015

The UK Government's aim is to demonstrate that all necessary measures are being taken to ensure gas infrastructure adequacy across EU Member States and that safeguards are in place to allow for exceptional climactic conditions or disruptions to supply.


Secure

ENERGY TRILEMMA


Affordable

In early 2008 it was estimated by Energywatch that there were around 4.5 million households in fuel poverty in the UK, with just over 3 million in England alone: this was more than double the number in 2003.


Sustainable

Energy companies have a vital role in facilitating the transition to a low carbon economy. The Climate Change Act established a target for the UK to reduce its emissions by at least 80% from 1990 levels by 2050.

Our commitment

As an industry we need to better understand the opportunities gas can afford us in the UK, particularly in the context of four key priorities for customers; supply of renewable gas, domestic heat, transport and network capability.

We are committed to seeking the lowest cost outcome to deliver our carbon reduction targets.

Supply of renewable gas

What should the energy mix look like?

The debate over how to decarbonise domestic heat across all UK homes is picking up momentum and the Government is now beginning to recognise the potential for renewable gas to contribute to the UK's low carbon economy. Renewable gas (methane-based gas, biomethane or Bio substitute natural gas (BioSNG)) can be produced from organic or landfill waste and injected into the gas grid and will therefore contribute to decarbonising energy supplies.

The question is "How do we address the energy trilemma when it comes to supply?"

We support the role of renewable gas as an important part of the energy mix – now and in the future – including storing it in the gas grid so it's ready when we need it.

This presents a number of challenges:

Affordability

It may be easy to introduce a policy for new homes but it's difficult and costly to retrofit the whole of the current housing stock with a different energy supply. This is particularly important considering 80% of the buildings we'll have in 2050 already exist today.

Security

Are we confident that the electricity grid would be able to cope with peak day and peak year demands? Even our best case scenario still has domestic and commercial heating delivered through hybrid electric and gas systems.

Sustainability

How can we tackle the energy that's wasted in turning renewable gas into electricity?

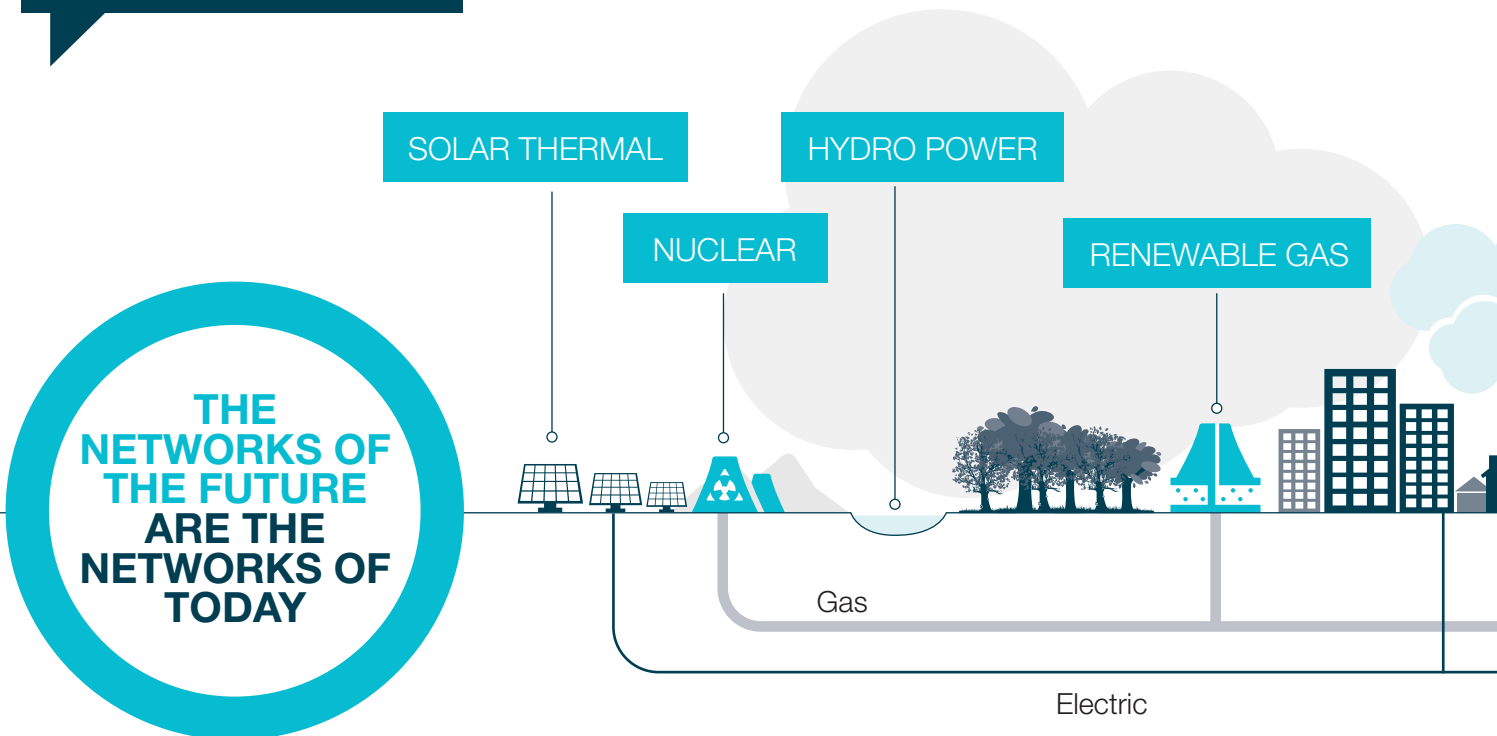
Meeting demand

Can we deliver what customers want? We already know consumers prefer gas cooking, and it would take a long time to persuade them to change over to electricity in their homes.

Energy policy

Current UK energy policy focuses on electrification for home heating. But that isn't the only option. Electricity is likely to be more expensive for consumers, may not meet future demand and may not achieve the targets for cutting carbon pollution set by The Climate Change Act 2008. This Act commits the UK to reducing total emissions by at least 80% in 2050 from 1990 levels. We believe that gas will play a crucial role as a bridging fuel as the energy system becomes carbon-free.

National Grid is at the forefront of developing innovative solutions that could use the existing gas networks while supporting the need to cut carbon. We could also look at how gas can offer greater "conversion efficiency".



Take fossil fuels, for example. When power stations convert these fuels, about half of their energy (40% to 65% depending on the fuel type) ends up as electrical energy. On top of this, power stations consume some energy themselves; even more is lost during transmission over the national grid.

Of course we also need to consider how we encourage that the right forms of waste go to the right energy conversion process.

On this basis, should there be a stronger emphasis on technologies such as renewable gas for heating our homes?

Investment

It's important to understand how investment in the gas network is being increased, and how innovation and incentives play their part.

There is a framework in place that enables 0.7% of revenue to be invested in innovation and we're already seeing the benefits, particularly in biomethane.

Key questions

- Can a more diversified supply ensure reliable sources of energy?
- At what cost should electrification be prioritised?
- How can gas better contribute to meeting challenging sustainability targets?
- How can we integrate waste and energy policy?

Renewable Gas and the low carbon economy.

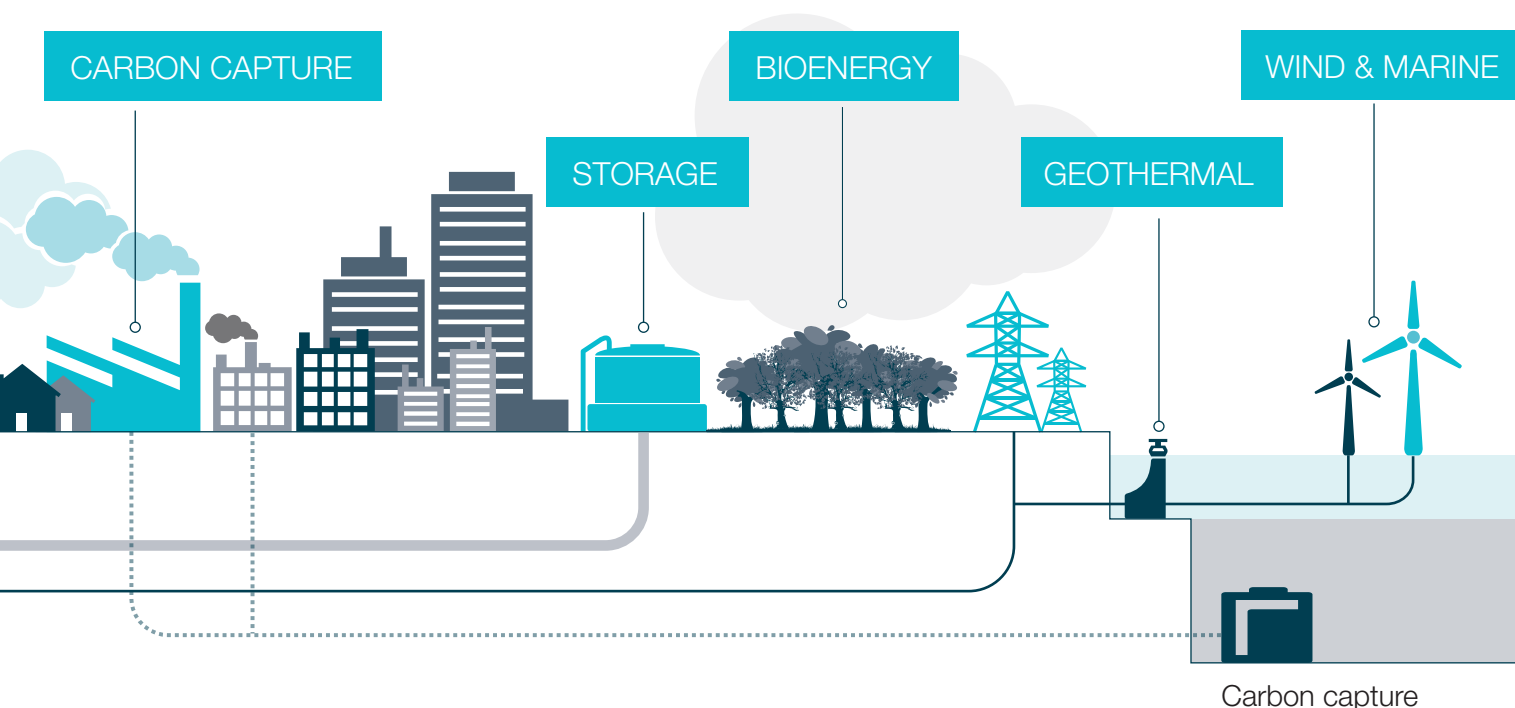
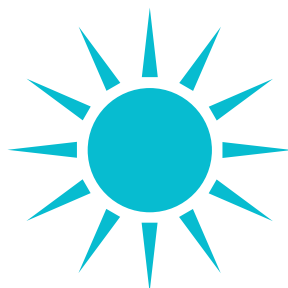
Renewable gas can be produced through Anaerobic Digestion from biodegradable matter such as food waste, sewage or energy crops or through Gasification (a process that converts organic or fossil contaminated based materials into carbon monoxide, hydrogen and carbon dioxide) of household waste material or biomass.

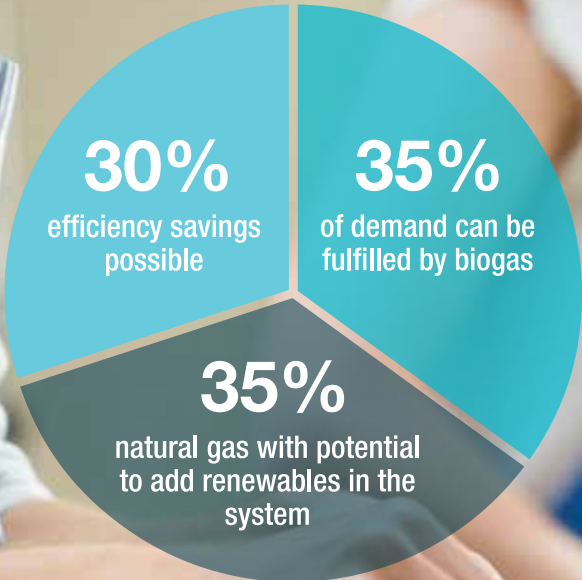
Through injection into the network renewable gas provides a sustainable, flexible and economic solution that could provide a significant contribution to the UK's heat demand by 2050. It also meets the Government's requirements for reducing landfill waste and greenhouse gas emissions and for meeting energy demand using sustainable resources.

Keeping gas as gas?

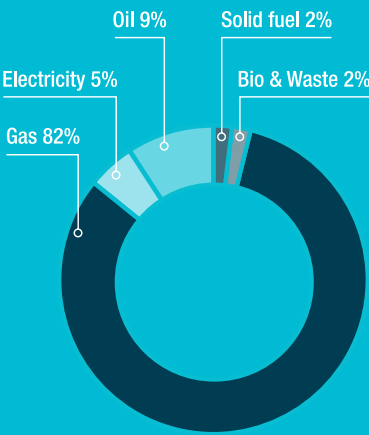
Unfortunately, much of the renewable gas generated today is being used to make electricity. This is because the price differential and policies such as the Renewable Heat Incentive make it more attractive to turn gas into electricity.

But we have to ask whether this is the right way to use a renewable resource, especially if it increases energy loss.

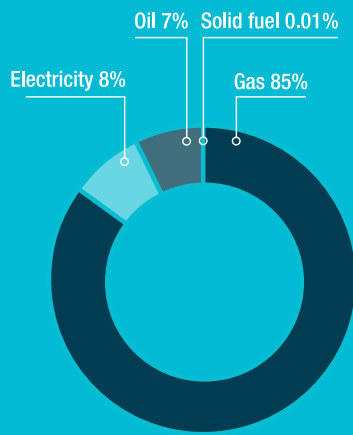




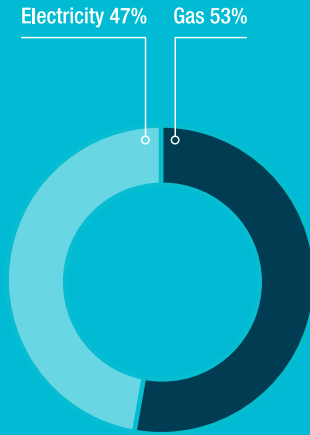
2010 end use by fuel



Space heating



Hot water



Cooking

Domestic heat

Context

We use 321 TWh to heat our homes each year – that's the equivalent of heating the water to run eight baths per day per household. But if the UK population is to increase by 14 million by 2050, with energy usage remaining relatively constant, how will we ensure that we can still meet customers' needs?

Two questions arise. Are we giving customers what they want in our future planning? Do we know what the customer of the future looks like?

Are we giving customers what they want?

According to research by the University of Exeter², consumers like gas because: it's easy to control and maintain; it's reliable and familiar; and it's well supported by a mature market that provides suppliers, boilers, installation and maintenance. Understanding customer choices is important because they're driven by a huge range of factors such as cost, hassle, indifference and lack of knowledge.

We need to go back to the energy trilemma – affordability, sustainability and security – and consider how this affects customers' decision-making and how we might influence their thinking.

Being less wasteful

The future domestic heat sector must tackle two important challenges. Firstly, consumer behaviour needs to change to reduce demand. Secondly, the energy industry needs to offer solutions that are as good as the energy options consumers enjoy today, at affordable prices.

Does that mean we will have to tailor our solutions for different customer sectors and understand the natural resources available geographically?

There is no single solution for moving to carbon-free heat. The UK must take a balanced approach with gas, heat networks and electric heat all playing their part. We ask the UK Government and policy-makers to ensure future heat policy provides long-term certainty for customers.

Consistently meeting demand

We know there will be a move to increase the use of electricity for heating in the future and the demand for gas will decrease. But, across all the future scenarios we have run, we believe gas will still be required for heat, particularly on peak days.

So how can gas and investment in new technologies help enhance flexibility and reliability of supply on the coldest days as well as at peak demand points? Would 100% electrification keep the power on 24 hours a day, every day of the year? We need to better understand how gas can supplement electrified heat and how we can use the existing network more efficiently.



**321 TWh used each year =
8 baths per day per household**

Key questions

- Are we delivering what our customers want?
- Can the ambitions meet the reality?
- How large is the funding gap to meet those ambitions and who should fill it?

Investment and innovation

We all know that new technologies aren't adopted overnight, but we should take account of the lead times for uptake and be realistic. Incentive schemes have been in place for a number of years to improve domestic heat efficiency, and yet take-up is slow. So what does the opportunity look like?

- Seven million homes would benefit from solid wall insulation, which would reduce demand by 10%.
- The continuation of A-rated boilers at current replacement levels will reduce demand by 10%.
- Smart thermostats are beginning to catch on. If they're GPS-enabled, and can turn on and off when needed, estimates suggest a further 10% reduction in demand.

What seems clear is that gas supports new energy innovation and develops clear pathways for the delivery of new technologies, such as gas heat pumps, micro combined heat and power (CHP) and fuel cells. These will enable more efficient use of gas in homes.

What we must not do in developing our approach to domestic heat, however, is risk any increase in the numbers of families living in fuel poverty. Are there areas that would benefit from gas, at least in the interim, to reduce heating costs and carbon content for customers?

Finally, are we sure that current and planned incentives are shaped in the right way for our customers? Are they too one-sided already?

Transport

Did you know 20% of the total transport sector greenhouse gas emissions comes from the UK's 208,000 heavy goods vehicles (HGVs)?

We believe this represents a huge opportunity for the gas network. We could significantly reduce the transport sector's carbon output if we use compressed natural gas (CNG) to fuel commercial vehicle fleets.

There are clear environmental and cost advantages in using CNG in the transport sector. And, as 95% of the UK's major distribution centres are within 2 km of our gas mains infrastructure, the existing UK gas networks are well placed to support the supply of CNG.

So, given these benefits, why hasn't CNG become the preferred fuel?

Key questions

- How do we enable the transport sector to reduce its carbon footprint?
- What steps do we need to take to move the vehicle fleet forward?
- What investment is required in the National Grid network? Do we need government incentives for fuel companies and fleet owners?
- How do we change hearts and minds? We can't assume "if we build it, they will come".
- Where is the tipping point for take-up?

What is CNG?

Compressed natural gas is methane stored at high pressure. It can be used in place of petrol and diesel and has many benefits:

- CNG produces fewer undesirable gases than diesel and petrol
- CNG is a cheaper fuel source and can save up to 40% in costs
- CNG is safer than other fuels when there's a spill because natural gas is lighter than air and disperses quickly when released
- CNG can be found above oil deposits; it's also collected from landfills or wastewater treatment plants, where it's known as biogas.

The challenge

Despite the advantages, using natural gas for vehicles has several limitations, including the storage and infrastructure that's available for delivery and distribution at fuelling stations.

To help stimulate the market, we've invested in building a refuelling facility for trucks that use liquefied natural gas (LNG). It should be up and running early 2016. We can also make good use of the UK's "back to depot" refuelling structure. As major infrastructure is already in place near industrial and commercial depots and throughout the main road arteries, very little new construction is needed.

The Department for Transport's infrastructure road map to 2030 incorporates the potential of gas. Its clear policy supported by incentives over the next two decades could make a significant contribution to reducing transport emissions in the medium term. This will help to maintain the fuel price differential and provide haulage companies with more reliable returns on their investment. They might then choose this lower carbon technology instead of diesel.

Case study

National Grid is working with the transport sector through the Natural Gas Vehicles network and has a project underway with CNG Fuels and the John Lewis group. This project aims to demonstrate the benefits of using our existing gas distribution network to connect a refuelling facility for CNG vehicles.

The key objectives are to examine the potential carbon reductions as well as the improvements to air and noise pollution that natural gas vehicles will bring.

Philip Fjeld from CNG Fuels says:

"Our customers can save more than 40% of their diesel cost, even after the recent drop in diesel prices, and cut CO2 emissions by more than 20% by using CNG. If fleets choose to fuel their trucks with Bio-CNG, they will be running on 100% renewable gas."



CNG: Benefits case

Transport has a key role to play in the decarbonisation of the UK's energy sector. We ask the UK Government to support compressed natural gas as the fuel of choice for heavy good vehicles and buses.

10-30%

Lower well-to-wheel CO₂ emissions



HGVs equate to 1.5% of road users but account for

20%

of road greenhouse gas emissions in the UK.



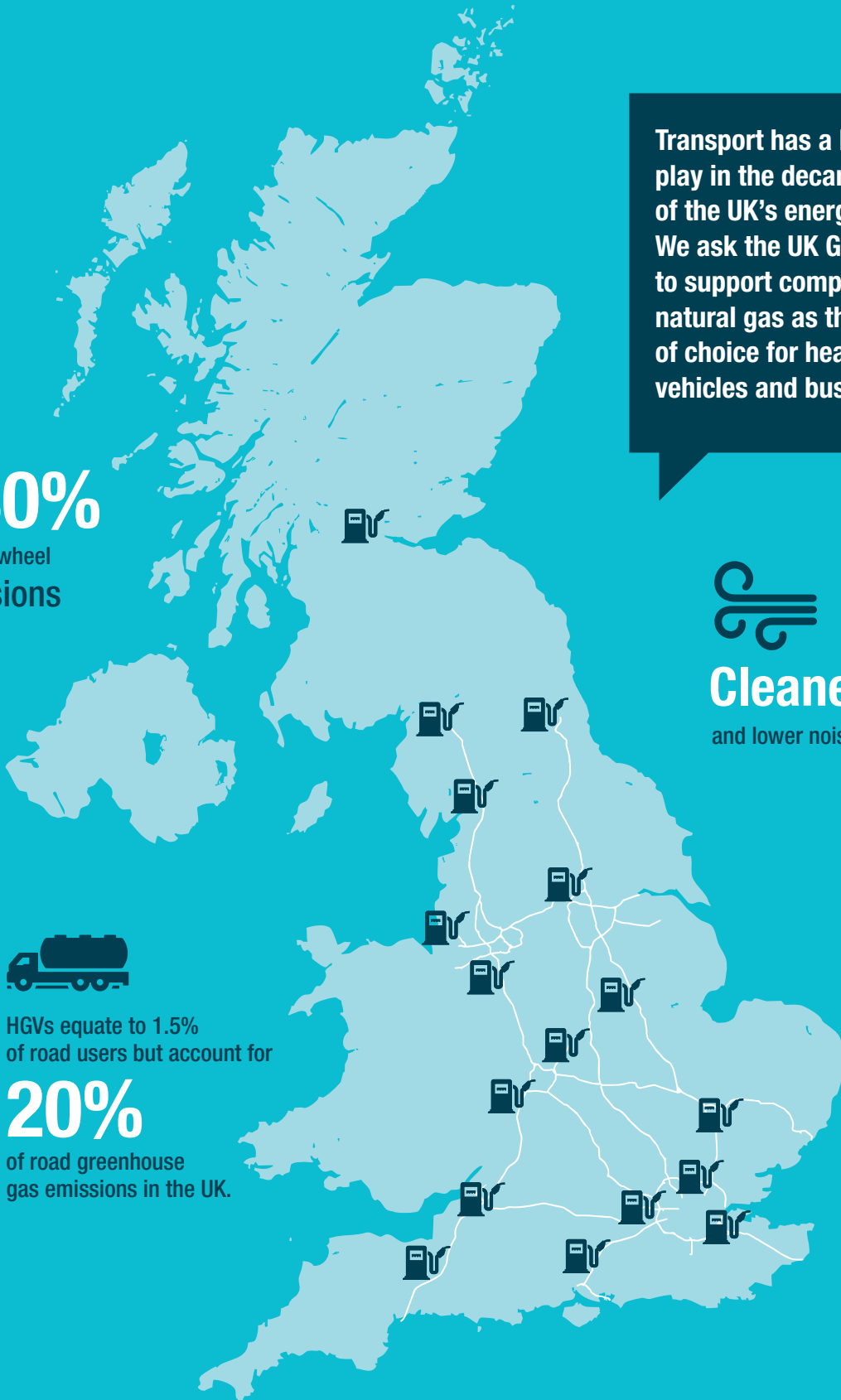
Cleaner air

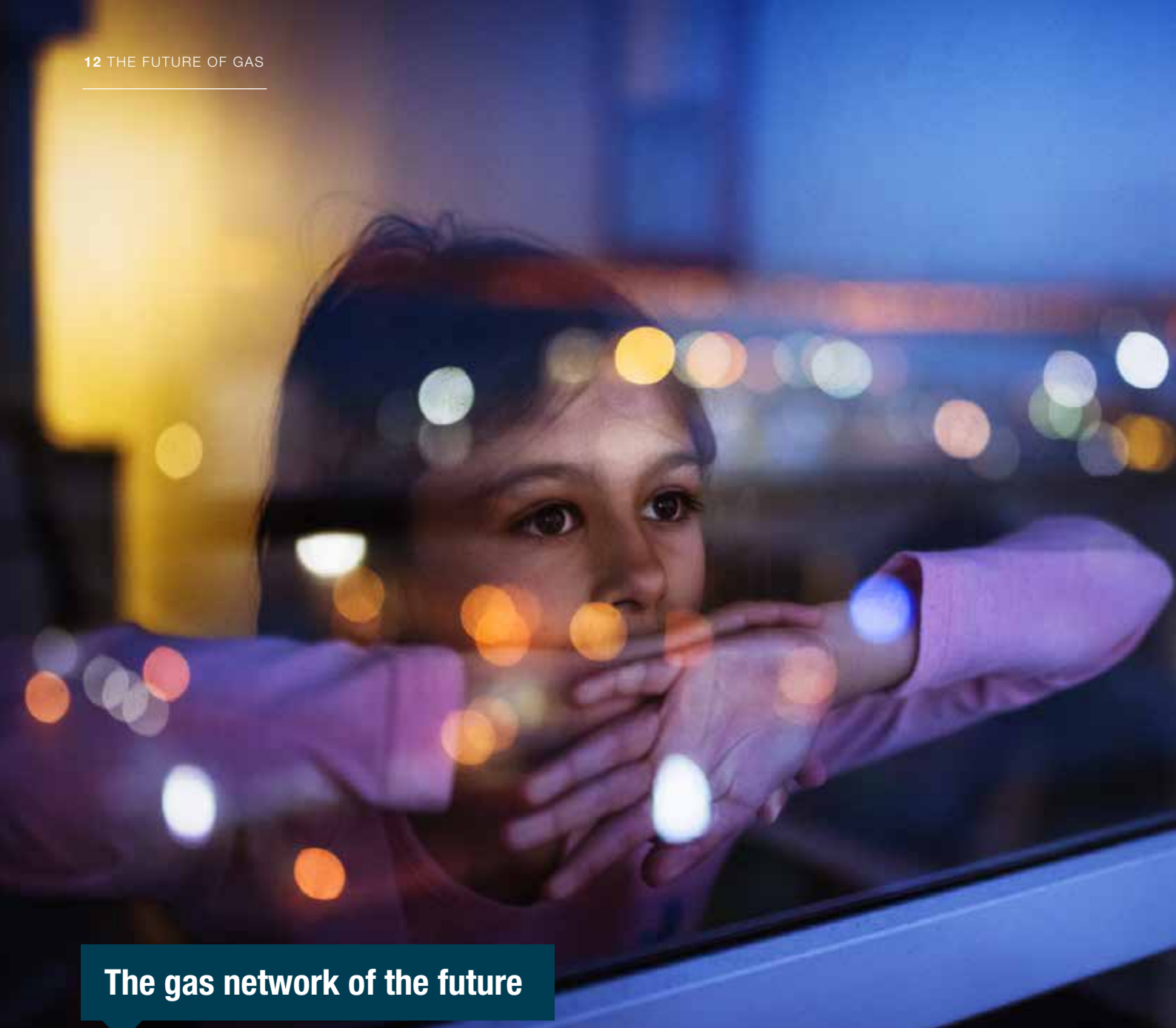
and lower noise levels



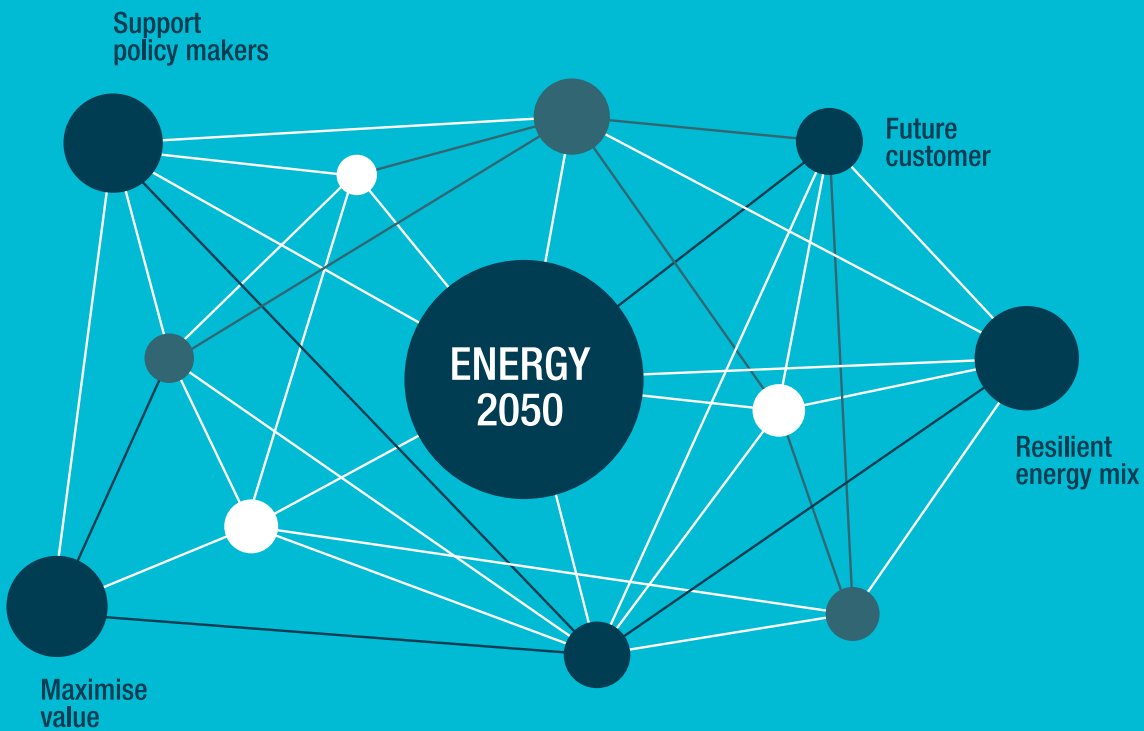
40%

fuel cost saving compared with diesel





The gas network of the future



Network

The context

We want tomorrow's energy infrastructure to meet the needs of tomorrow's customers. To do this, we need to understand the capability and versatility of today's gas network, what our future customers will look like and the role of gas in helping to power our future economy.

The current gas network is sophisticated and resilient. Its jigsaw design makes it versatile and able to transition parts from one energy solution to another. The network is flexible, too, coping well with day-by-day changes in demand as well as seasonal shifts.

The challenge

So, how does this existing system need to be invested in to ensure that it remains flexible, or to change to meet future customer need and why is it important to meeting the demands of the energy trilemma – affordability, sustainability and security?

We know the UK population is increasing more quickly now than it has over the past 35 years, and is becoming older. But how will this affect demand, and where?

Estimates suggest that more young people will be living at home rather than moving out, so there'll be a need for more space heating in older infrastructure. Demand won't be evenly spread, either. Areas such as Somerset and Shropshire may have populations where more than 50% of residents will be over 65 years of age – up from 30% today. However, in Manchester, only 12% of the population is predicted to be over 65 by 2050. So the demand for heating could be significantly different from town to town, county to county. How can gas contribute to helping UK Plc manage these changes?

The opportunity

We have a number of technical solutions to explore, and we need to demonstrate the benefits of the current network.

One key fact is that we have a gas network of 284,000 km spanning the UK, and we're already investing in it. The programme to replace the 100-year-old iron mains will result in a better network for the future, with low wastage and low leakage.

The gas network is also extremely flexible and reliable because it's made up of smaller cells of network that can be blocked off or reopened when needed. This could not only be a useful contingency for disaster planning but also help us cope with shifts in population growth. But how could we make the network work harder and more efficiently, particularly in times of financial constraint?

By introducing new sources of gas into the network, we can use an existing asset, make the UK's energy infrastructure more reliable, meet the goal of carbon reduction and provide cost-effective solutions. To get the most benefit from renewable sources such as solar and wind power, we need to be able to capture and store the energy. We already have conventional batteries

We ask the Government to consider a mix of investment across gas, electricity, renewables and other sources so we can balance the needs of today's customers and those of the future.

Key questions

- How safe is it to store hydrogen in the gas network?
- What will customers of the future look like? What will be their geographical distribution?
- What are the investment requirements? And what are the most cost-effective ways of making sure we'll be able to deliver energy in the future?

and pumped-storage hydroelectricity, but could we use the gas network as a battery? To give this potential energy reserve a sense of scale, if we turn all the current UK wind power into hydrogen for injection into our network, this would only represent 5% of the potential hourly throughput. As an example, Germany are exploring technology to turn power into gas – is it time for the UK to test its ability to utilise this in our UK energy mix?

Finally, if we decide to make the transition from all forms of gas to electricity, when would we need to start decommissioning the gas grid? In other words, when would other renewable technologies and the full electrification of heat be in place to allow the network to be withdrawn? What would be the financial implications of this for customers?

What next?

Delivering the energy needs of over 23 million customers across the UK affordably, securely and sustainably is an increasingly complex task. As an industry, we all have a role to play in supporting policy makers to make the right decisions for the long and short term to ensure we continue meeting those demands.

The Future of Gas series will look in detail at the key priorities for addressing how gas could, and should, be part of the energy mix.

However, we need to take a united approach, with collective responsibility, to presenting and raising awareness of the options, opportunities and challenges ahead. So we invite you to contribute to this series of thought-leadership papers, which will focus on:

- **Renewable gas (January 2016)**
- **Domestic heat (February 2016)**
- **Transport (March 2016)**
- **Network capability (April 2016)**

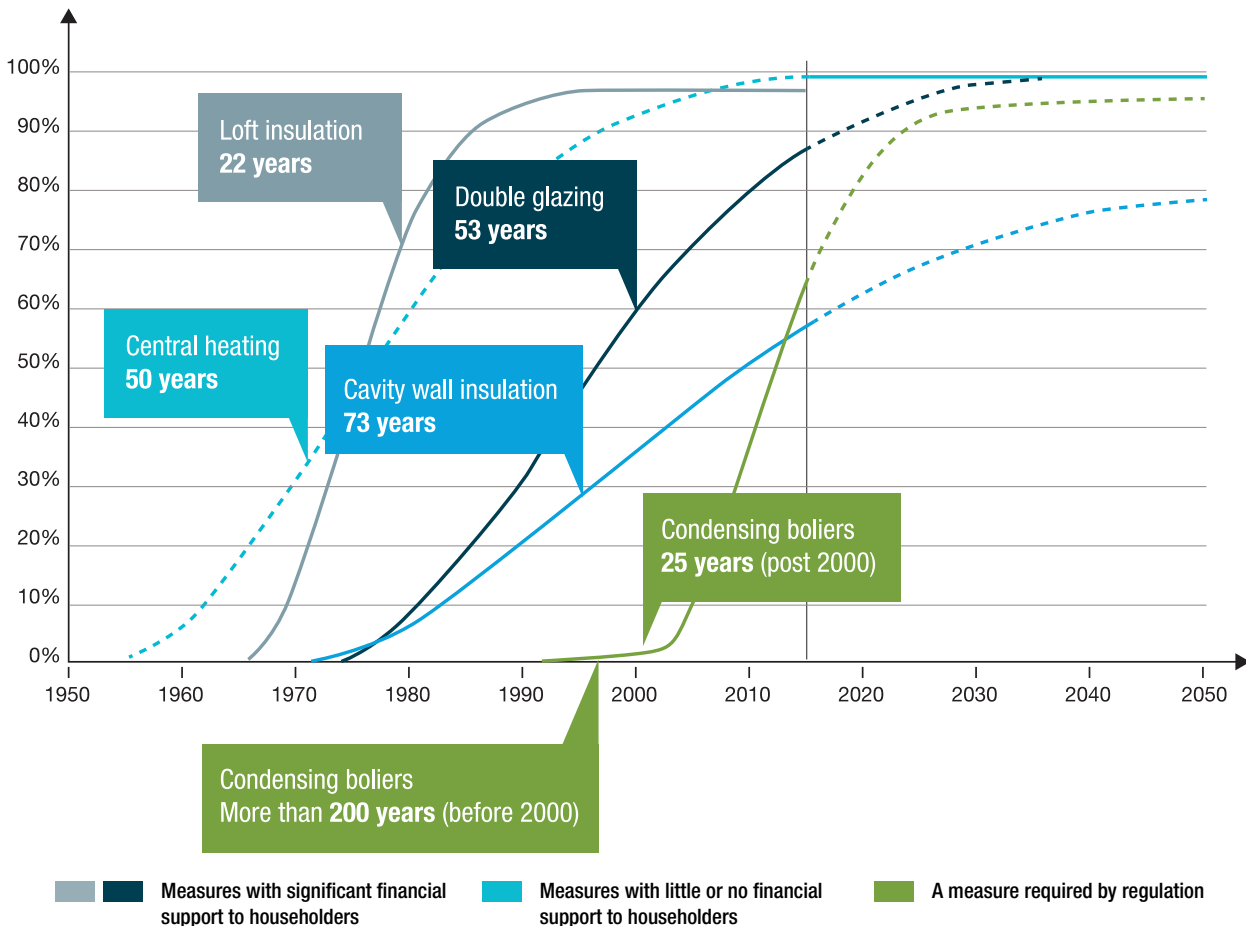
A final, concluding report bringing together all these papers will be available in late April 2016.

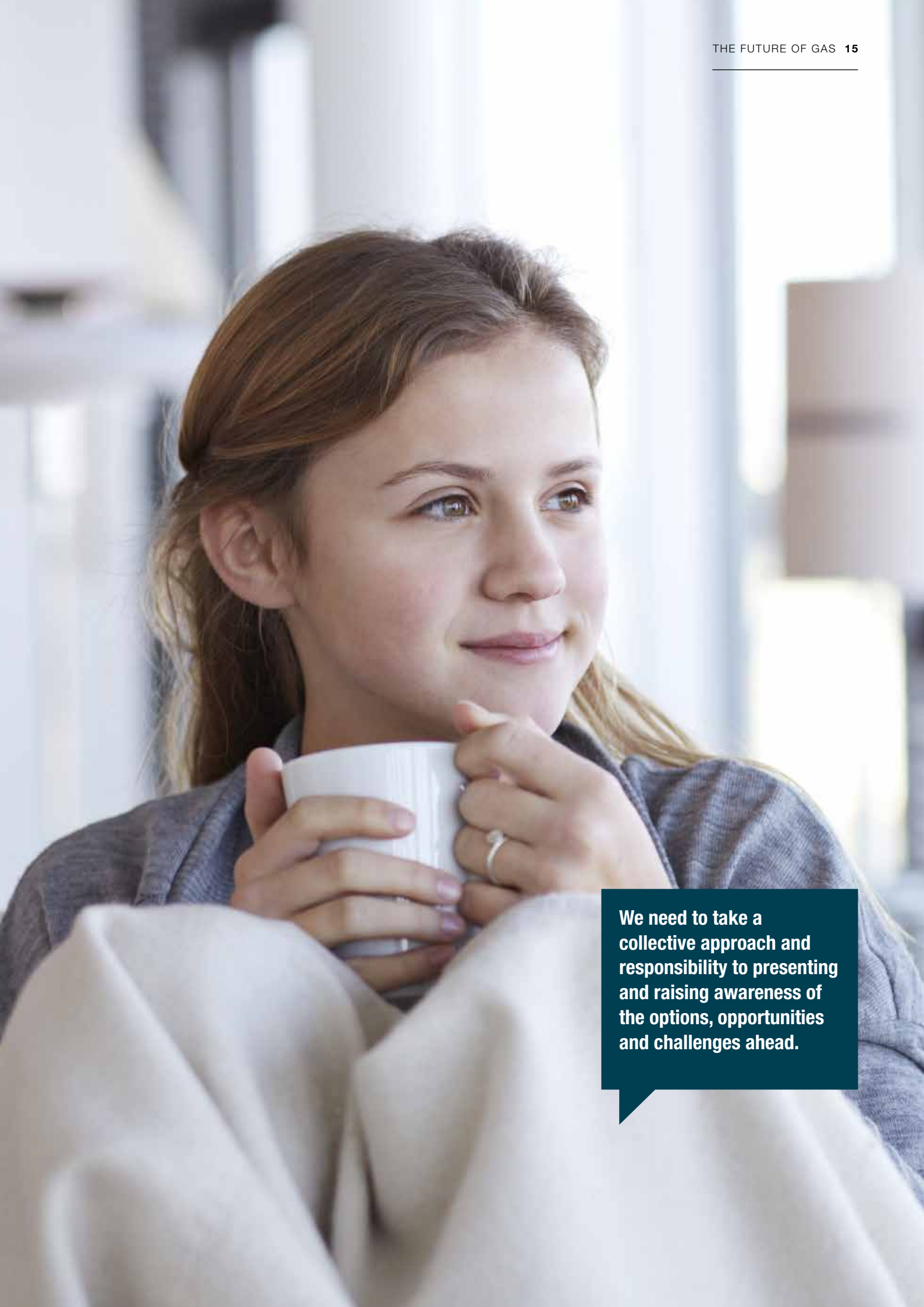
For more information about how to get involved please contact us at futureofgas@nationalgrid.com

The papers will be published online at www.nationalgrid.com/futureofgas

Time for change –

The chart below shows the time it takes consumers to adopt home energy efficiency measures. We need to understand that it takes time for consumers to change; for example, replacing appliances only at end of life which means it can take decades for changes to take effect.





We need to take a collective approach and responsibility to presenting and raising awareness of the options, opportunities and challenges ahead.

Have your say

We'd like your thoughts and comments on the points raised in this document, so here's a quick summary of the questions we have posed:

The challenge and the opportunity

- Should we use and store different forms of energy?
- What can we do with excess electricity energy when the demand is low?
- What is the role of renewable gases?

Supply of renewable gas

- Are we confident that the electricity grid would be able to cope with peak day and peak year demands?
- How can we tackle the energy that's wasted in turning renewable gas into electricity?
- Can we deliver what customers want?
- How can gas better contribute to meeting challenging sustainability targets?

Domestic Heat

- Are we giving customers what they want in our future planning?
- Will we have to tailor our solutions for different customer sectors and understand the natural resources available geographically?
- Are there areas that would benefit from gas, at least in the interim, to reduce heating costs and carbon content for customers?
- Are we sure that current and planned incentives are shaped in the right way for our customers? Are they too one-sided already?
- How large is the funding gap to meet those ambitions and who should fill it?

Transport

- How do we enable the transport sector to reduce its carbon footprint?
- What investment is required in the National Grid network to enable a CNG network to support customers?
- Do we need new government incentives for fuel companies and fleet owners?
- Where is the tipping point for take-up?

Network

- Should we invest in the existing system to ensure that it remains flexible and meets future customer needs?
- How could we make the network work harder and more efficiently, particularly in times of financial constraint?
- How safe is it to store different forms of renewable gas, such as hydrogen in the network?
- What investment is required and by whom?

Disclaimer

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A young child with light brown hair is looking out a window. The child is wearing a light blue shirt. The background is a blurred view of a window with vertical blinds.

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